Open Channel

by Joseph J. Carr

Telephones and EMI

Interference to telephone receivers is almost always the fault of the receiver or its wiring. That means the users or owners of the telephone system are at fault, and will have to bear the expense and effort to clear up the EMI problem.

Federal Communications Commission

Basically, the Federal Communications Commission (FCC) has no responsibility in the matter of EMI to telephones. Ever since deregulation, there has been no reason why the FCC is interested. The FCC regards this as a matter between the parties involved, and does not get involved. The FCC does, however, receive a large number of complaints about EMI to phone systems. As a result, their Compliance & Information Bureau publishes a booklet that may be of some help: *What To Do If You Hear Radio Communications On Your Telephone* (Bulletin CIB-10). It can be downloaded at **http://www.fcc.gov**.

Telephone Company

The local telephone company may view EMI problems as a matter of interest to those involved, and of no particular interest to themselves. Their responsibility ends with the "drop" at the service entrance to the business or home.

Ever since deregulation, the local phone companies have not had any interest beyond the drop. However, some do offer wiring contracts where the user pays a monthly fee on their telephone bill to have the phone company be responsible for the wiring.

Most such contracts will exempt the telephone receiver itself. Nonetheless, these contracts are worth exploring if there is an EMI problem on the telephone lines. Most such EMI problems are line problems, especially in the 500 KHz to 40 MHz region. Otherwise, if you are going to involve the telephone company discuss who is going to pay them.

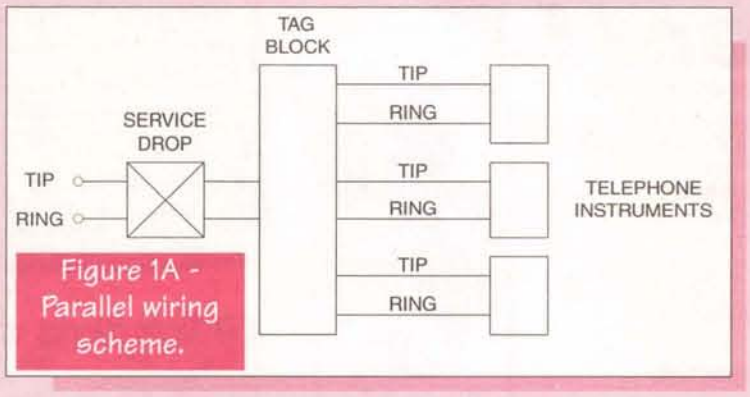


Figure 1A - Parallel wiring scheme.

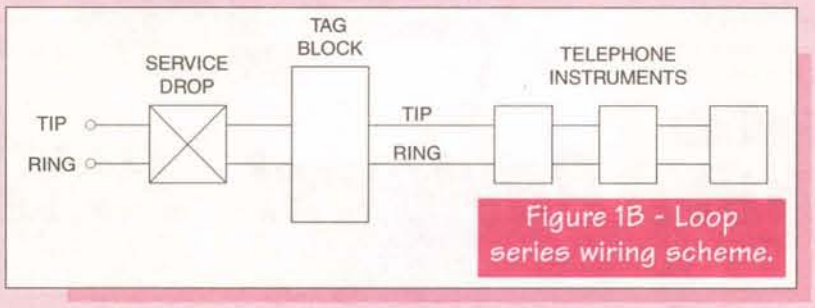


Figure 1B - Loop series wiring scheme.

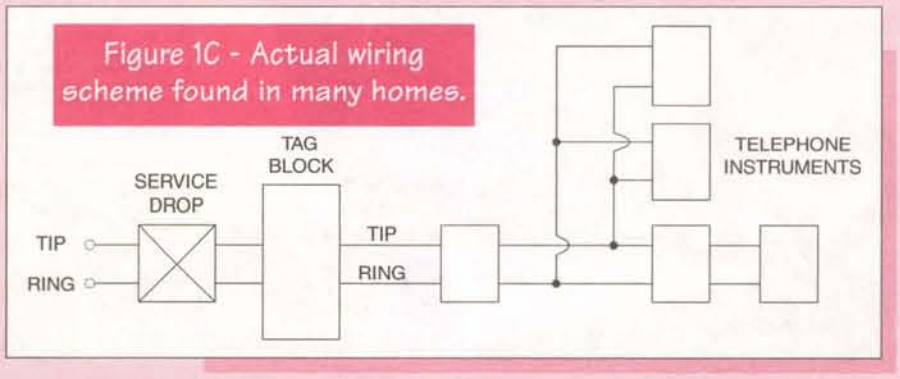


Figure 1C - Actual wiring scheme found in many homes.

Radio Owner

FCC regulations state that radio signals must be free of those characteristics that interfere with other services. That means radio and television services, not telephones. The radio owner and operator have no responsibility towards the telephone owner. That said, it is incumbent on the responsible operator of the equipment to try to provide the solution to the interference problem. But what that means is open to discussion.

It may mean, for example, handing out filters. Or it may mean handing out good advice. The issue of personal diplomacy is of primary concern here because the person being interfered with feels aggrieved.

Telephone Manufacturer

Ever since the deregulation of the telephone industry, there has been a tremendous number of firms providing telephones to the US marketplace. Some of them deal with EMI complaints effectively, others do not. You would think that manufacturers and importers of telephone equipment would be interested in the interference free use of that equipment. Such is not always the case.

In fact, several importers do not have the technical capacity to be of much use to the user. Some manufacturers, however, are a little better and will even supply filters for those customers who experience interference.

Telephone Owner

The responsibility for EMI proofing telephone equipment falls squarely on the end user of the equipment. Regardless of whether the interference is due to conducted pick-up in the wiring, or due to direct pick-up in the instrument itself, there is nothing the radio operator can do to eliminate the problem.

LASERS & ACCESSORIES

HELIUM NEON LASERS
- Complete Systems
- Plasma Tubes
- Power Supplies

ACCESSORIES
- Optics
- Electro-Optics
- IR Viewers
- Books & More

DIODE LASERS
- Visible / IR
- Complete Modules
- Collimating Optics
- Drive Circuits

FREE CATALOG
WEB SITE:
www.
mi-lasers.com

MEREDITH INSTRUMENTS

Phone: 623-934-9387 • Fax: 623-934-9482

Write in 29 on Reader Service Card.

Professional 10 HOUR RECORDER
Factory Direct
"BUILT LIKE A BATTLESHIP"

- Heavy duty commercial recorder - NOT improvised from consumer models
- 12, 14, and 16 hour models also available
- BUILT-IN voice activation (add $30)
- Applications information included
- Dimensions: 11.5 x 7.0 x 2.75"

SPECIAL Nuts&Volts Price..
$159

COD's OK. Sorry, no credit cards. Free catalog USA only; other countries $5. Price Includes UPS to 48 States on Pre-Paid Orders

Viking Systems International 100 North Hill Drive #42, Brisbane, CA 94005
Phone (415) 467-1220 • Fax: (415) 467-1221 • Web: vikingsysintl@aol.com

Write in 30 on Reader Service Card.

Telephones and EMI

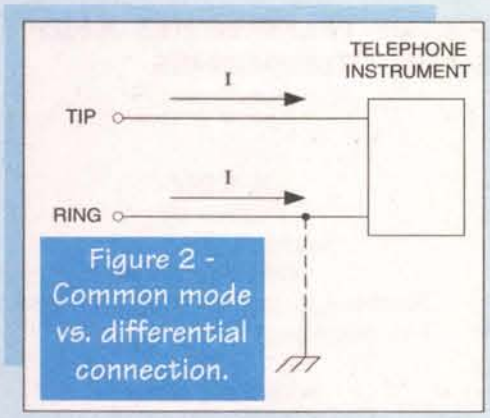


Figure 2 - Common mode vs. differential connection.

The problem is due to poor design of the telephone equipment selected by the consumer. The use of a filter should be explored. Failing that, a consumer may opt for one of the EMI-proof telephones that are offered.

A problem is that the interfering station appears to be doing something to the telephone. That sometimes produces a bitter consumer who demands that the problem be cleared up on the transmitter end. A little "personal diplomacy" will go a long way towards settling that issue, I suspect.

Technical Issues

All that has gone before in this article assumes that someone will get the job of defining a solution to the EMI problem. In this section, we will discuss the telephone wiring system and what can be done about it.

Figure 1 shows two forms of wiring that may be present in a home or business. Figure 1A shows the parallel wiring scheme, and Figure 1B shows the loop series wiring scheme. In the parallel scheme, there are as many wires from the junction block where the phone company's interest terminates as there are telephones. In the loop series wiring scheme, there is one pair of wires leaving the junction block, and the telephone instruments are daisy-chain wired from them. In truth, there might be a situation where both methods are used (which would reflect a user wiring scheme) ... as shown in Figure 1C!

There will be a fused lightning arrestor present at the drop. This lightning arrestor might be corroded, or it may be non-linear. In the case of corrosion, the non-linearity may be due to oxides or bimetallism causing the device to act like a diode. In either case, the non-linearity will act like a diode and cause rectification of RF energy. This, in turn, causes the EMI.

Twisted Pair, Flat (Parallel), and Shielded Wiring

Twisted pair wiring is superior to flat wire where EMI is concerned. It gets this attribute because of the fact that twisted pairs are self-shielding where flat wire is not. Twisted pair wiring can pass through noisy environments and be EMI free.

Unfortunately, most telephone wiring in the United States appears to be flat wire, eliminating the self-shielding aspects of twisted pair wiring. If you have a situation where there is a lot of flat wire involved, then it would be prudent to change it. For really difficult cases, use telephone company Category 3 or Category 5 wiring, even if the cost is high. Alternatively, you can use shielded wire yourself. The shield will protect against the EMI, but is terribly expensive.

It is good practice to ground unused wires or pairs of wires in a bundle. If the unused wires are grounded at the service entrance to the house, then there will be a decrease in susceptibility to EMI.

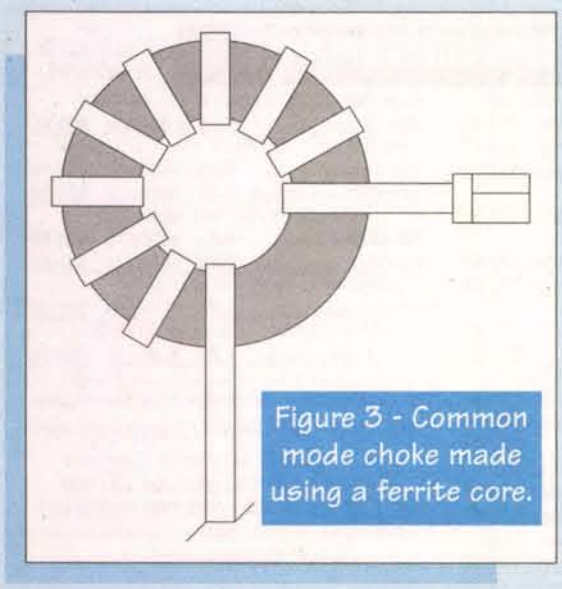


Figure 3 - Common mode choke made using a ferrite core.

Common Mode vs. Differential Mode

The telephone system is normally common mode, which is to say that it is balanced with respect to ground. Figure 2 shows this condition. When common mode integrity is maintained, the currents (I) flowing due to RF will be equal, nulling out at the instrument. It is not guaranteed that common mode lines will be EMI-free, but there is a higher probability of that condition existing.

Occasionally, a differential mode condition exists. This is an unbalanced condition. This is illustrated by the grounded condition in Figure 2. This mode can exist because of staples used to mount the wire breaking one insulator but not the other, by insulation breaking down, and by wiring errors. When the differential mode exists, the telephone will still operate as before, but the susceptibility to EMI will be tremendously increased.

Resonances

The telephone wiring in a home or business acts like a random length or even long-wire antenna to signals in the 500 KHz to approximately 200 MHz region. In that case, there will be resonance effects, i.e., those lengths that are integer multiples of quarter wavelength. The effect appears to peak in the 1.6 to 15 MHz region, but is present throughout the region of the spectrum cited above. At these resonant points, there is an increased probability of EMI problems.

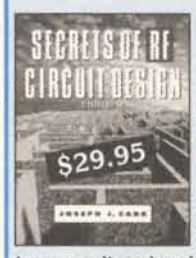
Telephone Ground

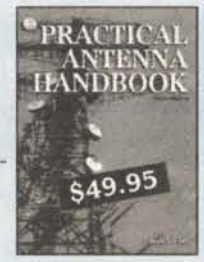
The telephone system is grounded at the service entrance and no other point. If grounds exist elsewhere, they must be dealt with appropriately ... remove them. A properly installed telephone ground will either use a separate ground rod or be tied to the power company's ground. But there is a kind of ground where the telephone ground is tied to a cold water pipe at one end of a house, and the cold water pipe is, in turn, grounded to the AC power mains ground at the service entrance. This is a bad practice, and should be eliminated.

Corrosion on the Connections

Corrosion can occur on wires in the telephone system. This occurs because of years of exposure in damp spaces. Corrosion can cause noise on the line (hissing and frying, or pops), as well as making the line more susceptible to EMI. The susceptibility to EMI occurs because corrosion makes a decent diode, especially when two metals are involved in the junction (e.g., tinned vs. copper). Wiring that is corroded should be replaced, or at least the corroded

JFETS
ULTRA LOW NOISE
LS843 - 3nV/Hz typ
TIGHT MATCHING
LS843 - 1 mV max
◇ N & P Channel
◇ Duals & Singles
◇ Custom Screening
◇ Die, SMT, Thru-Hole
◇ No Order Minimum
◇ COD's Accepted
Second Source for Domestic & Foreign JFETs & Bipolars
Full Service U.S. Manufacturer of Specialty Linear Products
LINEAR SYSTEMS
4042 Clipper Court
Fremont, CA 94538
510-490-9160/510-353-0261(Fax)
E-mail: 3623671@MCIMAIL.COM
Write in 31 on Reader Service Card.

2 Great Books
by Joseph Carr


SECRETS OF RF CIRCUIT DESIGN
From one of today's most respected electronics authors comes this pragmatic, intermediate-level guide to designing, building, and testing all types of radio frequency circuits. Filled with functional projects that demonstrate the principles of RF circuits, this revision of a bestseller also provides a handy parts list and sources of components.
PRACTICAL ANTENNA HANDBOOK


The most popular book on antennas ever written, widely known as "the antenna builder's bible."
This *Third Edition* is a work for anyone with an interest in antennas, from the newest of novices to the most experienced engineer. This empowering book gives you all kinds of projects and material that explains why what you did works.
As a paid subscriber to *Nuts & Volts*, you'll receive 10% off the list price!!
(See ad on page 87 for ordering details and other titles currently available.)

Telephones and EMI

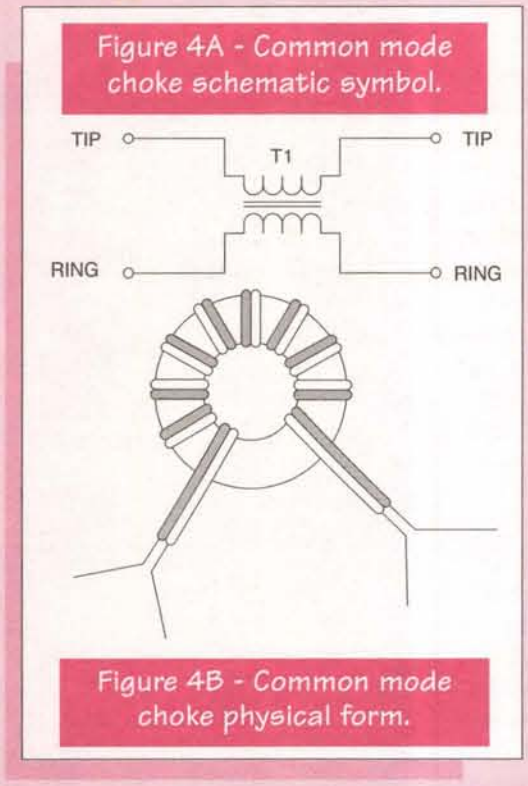


Figure 4A - Common mode choke schematic symbol.

Figure 4B - Common mode choke physical form.

portions eliminated and soldered.

Substandard Wiring

There is a substantial possibility of encountering substandard wiring in troubleshooting EMI to telephone problems. This is made especially likely now that consumers are doing their own wiring. Whenever substandard wiring is encountered, it should be replaced before any attempts — other than simple filtering — are made to eliminate the EMI. This is especially true if one of the wires is shorted to ground or there is corrosion present.

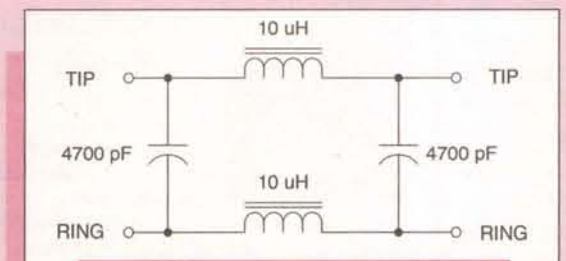


Figure 5 - Filter used for telephone EMI.

Telephone Classification

Telephones are classified according to type: plain old telephones or multi-featured. The plain old telephone is relatively free of EMI, but not entirely. This is due to the fact that the features of the other type require electronic circuitry in which there may be semiconductor junctions that can rectify RF. Generally speaking, the plain old telephone EMI can be dealt with using simple filtering (discussed later). Filtering alone may or may not help the multi-function EMI problem. In those cases, shielding may be in order.

Telephone Registration Numbers

Many telephones are sold in the United States with no importer or manufacturer listed. There will be a manufacturer's registration number present. In case you want to contact the manufacturer, the registration number can be interpreted for you by the FCC (Manager Part 68 Rules, 2000 M Street N.W., Washington, DC 20554). Once it is determined that the telephone itself is at fault, contact the manufacturer for information on fixes.

SOURCES OF RADIO-PROOF TELEPHONES AND RADIO FILTERS FOR TELEPHONES

RADIO-PROOF TELEPHONES:

TCE LABORATORIES, INC.
2365 Waterfront Park Drive
Canyon Lake, TX 78133
(830) 899-4575
Notes: Desk and wall models available. Will do custom orders for multiple-line phones, speaker phones, answering machines, etc. Advertises 30-day money-back guarantee.

PRO DISTRIBUTORS
2811 74th Street, Suite B
Lubbock, TX 79423
(800) 658-2027
Notes: Desk and wall models available. Advertises 30-day money-back guarantee.

RADIO INTERFERENCE FILTERS:

AT&T
(800) 222-3111
Notes: Also available at AT&T and GTE Phone Center stores.

COILCRAFT
1102 Silver Lake Road
Cary, IL 60013
(800) 322-2645
Notes: Filters for computers and printers also available.

ENGINEERING CONSULTING
583 Candlewood Street
Brea, CA 92621
(714) 671-2009
Notes: Also available filters for two-line telephones.

INDUSTRIAL COMMUNICATIONS ENGINEERS (ICE)
P.O. Box 18495
Indianapolis, IN 46218-0495
(317) 545-5412
Notes: Also available hard-wired filter for wall-mount telephone.

K-COM
P.O. Box 82
Randolph, OH 44265
(330) 325-2110
Notes: Also available filters for two-line telephones.

KEPTEL, INC.
56 Park Road
Tinton Falls, NJ 07724
(800) 883-8378

KILO-TEC
P.O. Box 10
Oak View, CA 93022
(805) 646-9645

OPTO-TECH INDUSTRIES
P.O. Box 13330
Fort Pierce, FL 34979
(800) 334-6786
(407) 468-6032

RADIOSHACK
Available at nearest RadioShack store.
Catalog #273-104.

SNC MANUFACTURING
101 W. Waukau Avenue
Oshkosh, WI 54901-7299
(800) 558-3325
(414) 231-7370

SOUTHWESTERN BELL FREEDOM PHONE ACCESSORIES
7486 Shadeland Station Way
Indianapolis, IN 46256
(800) 255-8480
(317) 841-8642

TCE LABORATORIES
2365 Waterfront Park Drive
Canyon Lake, TX 78133
(830) 899-4575
Notes: Also available filters for two-line telephones.

Do You Repair Electronics?
For only $7.95 a month, you'll receive a wealth of information:

Repair data for TV, VCR, monitor, audio, camcorder, & more.

Over 100,000 constantly updated problem/solutions plus...
- TechsChat live chat room.
- Private user discussion forums.
- Automated email list server.
- UL/FCC number lookup.
- Hot tips bulletin board.
- Manufacturer information.

To access RepairWorld, direct your internet browser to http://www.repairworld.com

RepairWorld.com
Electronix Corp. 1 Herald Sq. Fairborn, OH 45324 (937) 878-9878

Mr. NiCd — JULY 2000 SUPER SPECIALS! — THE BEST BATTERIES IN AMERICA!

Packs & Charger for YAESU FT-50R / 40R / 10R:
FNB-40xh Slim-NiMH 7.2v 650mAh $41.95
FNB-47xh (NiMH) 7.2v 1800mAh $49.95
FNB-41xh (5w NiMH) 9.6v 1000mAh $49.95
For YAESU FT-51R / 41R / 11R:
FNB-38 pack (5W) 9.6v 700mAh $39.95
For YAESU FT-530 / 416 / 816 / 76 / 26:
FNB-26 pack (NiMH) 7.2v 1500mAh $32.95
FNB-27s (5w NiMH) 12.0v 1000mAh $45.95
For YAESU FT-411 / 470 / 73 / 33 / 23:
FNB-11 pack (5w) 12.0v 600mAh $24.95
FBA-10 6-Cell AA case $14.95
Packs for ALINCO DJ-580 / 582 / 180 radios:
EBP-20ns pack 7.2v 1500mAh $29.95
EBP-22nh pk.(5w) 12.0v 1000mAh $36.95
EDH-11 6-Cell AA case $14.95
For ICOM IC-Z1A / T22-42A / W31- 32A / T7A:
BP-180xh pk. (NiMH) 7.2v 1000mAh $39.95
BP-173 pack (5w) 9.6v 700mAh $49.95
For ICOM IC-W21A / 2GXAT / V21AT:(Black or Gray)
BP-132s (5w NiMH) 12.0v 1500mAh $49.95

For ICOM IC-2SAT / W2A / 3SAT / 4SAT etc:
BP-83 pack 7.2v 600mAh $23.95
For ICOM 02AT etc & Radio Shack HTX-202 / 404:
BP-8h pack 8.4v 1400mAh $32.95
BP-202s pack (HTX-202) 7.2v 1400mAh $29.95
For KENWOOD TH-79A / 42A / 22A:
PB-32xh pack (NiMH) 6.0v 1000mAh $29.95
PB-34xh pack (5w NiMH) 9.6v 1000mAh $39.95
For KENWOOD TH-78 / 48 / 28 / 27:
PB-13 (original size!) 7.2v 700mAh $26.95
For KENWOOD TH-77, 75, 55, 46, 45, 26, 25:
PB-6x (NiMH, w/chg plug!) 7.2v 1200mAh $34.95

Mail, phone, & Fax orders welcome! Pay with Mastercard / VISA / DISCOVER / American Express
Call 608-831-3443 / Fax 608-831-1082
Mr. NiCd - *E. H. Yost & Company*
2211-D Parview Road, Middleton, WI 53562
CALL OR WRITE FOR OUR FREE CATALOG!
Cellular / Laptop / Videocam / Commercial & Aviation packs too!
E-mail: ehyost@midplains.net

Write in 32 on Reader Service Card.

Telephones and EMI

Capacitors

The capacitor is a differential mode filter of sorts, and can be used to eliminate EMI. Use a 0.001 mF to 0.01 mF, 1000 WVDC disk ceramic unit (the voltage rating is needed because the ring voltage can exceed 100 volts).

Unfortunately, this simple fix won't always work. At 3,000 Hz (the maximum frequency response of a telephone), the impedance of a 0.01 mF capacitor is about 5,300 ohms. Several capacitors will produce a value of impedance that may disrupt service, making it low volume.

The capacitor will not work in the case of EMI to a high speed MODEM. Even low value capacitors will exhibit enough phase shift to interrupt the operation of these devices.

Common Mode RF Chokes

If the telephone is responding to common mode signals, then a common mode choke may do wonders for the EMI problem. The simplest form of choke is the ferrite, such as shown in Figure 3.

Use the type 73, 75, or 77 ferrite material for the lower HF range, and type 43 ferrite for the VHF range. This type of choke is placed as close as possible to the instrument.

Figure 4 shows a common mode choke that is useful for EMI up to about 30 MHz or so. Figure 4A shows the schematic symbol, where Figure 4B shows the physical form of an actual choke.

The turns of the common mode choke are wound in the bifilar manner, i.e., they are wound together. This is done either by paralleling the wires, or by twisting them together prior to winding. If you plan to build your own, use about 28 turns of No. 30 AWG wire on a 0.50-inch form.

Filtering

There is a basic fact of life in telephone EMI problems: filtering eliminates a tremendous amount of it! The instrument can't respond to EMI if the RF that causes EMI can't get to the instrument. It's as simple as that!

A sample telephone filter is shown in Figure 5, although you will probably want to buy a filter rather than make one. It is most useful when the filter is placed as close to the affected instrument as possible.

When dealing with commercial filters, it may be necessary to work with several products, especially if the frequency of the offending station is not well established. The filters are made for different bands, and that factor alone makes them useful for different types of EMI.

Conclusion

Electromagnetic interference to telephone receivers is often difficult to nail down. Nonetheless, the EMI problem can be dealt with using the methods discussed in this article.

NV

Connections ...

I can be reached by snail mail at P.O. Box 1099, Falls Church, VA 22041, or via E-Mail at CARRJJ@AOL.COM.

Software for learning & designing

This new range of products, from Matrix Multimedia in the UK, includes resources and tools to help you learn about electronics and helping you to design electronic products and systems.

A complete course in electronics: Made up of 3 CD ROMs: Electronic Circuits & Components, Digital Electronics, and Analog Electronics.

A complete course in programming the PICmicro series of microcontrollers: the PICtutor CD ROM and development board. Comprehensive tutorials, assembler / send package, and flexible development board.

A course in **Filter design**: Filters CD ROM.

A **complete Electronics CAD suite**: CADPACK includes software for schematic capture, circuit simulation, circuit animation and even PCB layout.

CAD PACK
shareware available from: www.matrixmultimedia.co.uk /cadpack.htm

A scalable **digital logic simulator**: Digital Works allows complex digital logic circuits to be built and tested on-screen for learning logic design and

digital WORKS
shareware available from: www.dworks.co.uk

	Student	Institution	10 user
each program / CD ROM	$50	$99	$300
PICtutor CD + development board	$149	$300	-

CD ROMs now available from all Velleman distributors

Complete product descriptions available at:
www.matrixmultimedia.co.uk

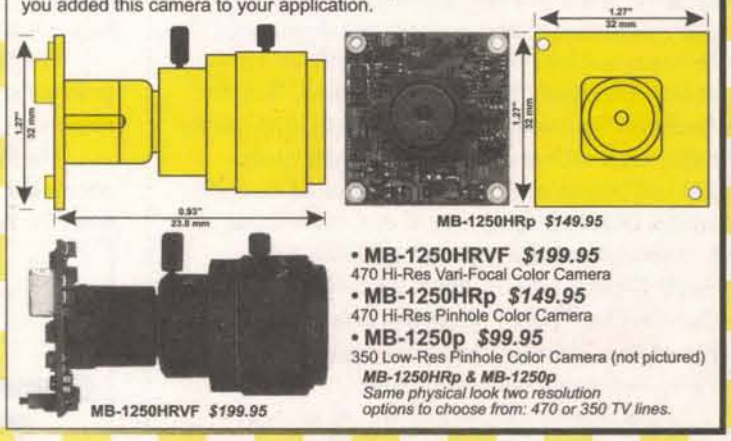
or order immediately at:
Bright Future
6540 Cedarview Court,
Dayton Ohio 45459-1214
Tel: (937) 438 5373 Fax: (937) 438-3229

Write in 31 on Reader Service Card.

Polaris can supply you with all of today's Hottest Video Technology, Micro Cameras to Professional Security Supplies

470 TV Lines Color "Micro-Zoom" Video Board Camera

470 TV Line Color Board Cameras, Technology has added high resolution to its smallest cameras, We've added a Vari-Focal lens to an already powerful board camera. The 4-8mm Vari-focal lens is a tool you won't be able to live without once you added this camera to your application.



- **MB-1250HRVF** *$199.95*
  470 Hi-Res Vari-Focal Color Camera
- **MB-1250HRp** *$149.95*
  470 Hi-Res Pinhole Color Camera
- **MB-1250p** *$99.95*
  350 Low-Res Pinhole Color Camera (not pictured)

MB-1250HRp & MB-1250p
Same physical look two resolution options to choose from: 470 or 350 TV lines.

Flat Screen TFT-LCD Monitors

TFT-4 *$209.95*
Color 4" Screen. (Size: 6"(W) x 4.5"(H) x 2"(D) An excellent 4" monitor for one camera monitoring or for setting up cameras during installation or maintenance.

COLOR 5.6" TFT and 6.4" TFT Monitors

TFT-5.6 *$429.95*
TFT-6.4 *$479.95*
(Includes: patch cable & power supply)

Wireless Video

Free Polaris Video Catalog

CM-500CBC, A tough aluminum cased Color CMOS camera with mounting bracket. BNC video & barrel power connection for Plug & Play hook-up. *View through standard VCR or Monitor!*

- 1/3" Color CMOS
- 380 - TV Line
- 1 LUX
- Lens 3.6 mm
- Auto Iris

CM-500CBC
$129.95

CMOS C-Mount B/W & Color Cameras

B/W Camera: CM-220 *$69.95*
Color Camera: CM-220c *$139.95*

15 Years of Quality Service

The CM-220 & CM-220c are truly outstanding performance cameras with 380 Line Resolution & C-Mount options.

Polaris Industries
http://www.polarisusa.com
1-800-752-3571
470 Armour Drive NE • Atlanta GA 30324-3943 • *Tech Info 404.872.0722* • FAX 404.872.1038

Write in 35 on Reader Service Card.